Multidisciplinary analysis of Roman silver coins

Lindsay MacDonald and **Mona Hess**, 3DIMPact research group, Department of Civil, Environmental and Geomatic Engineering, University College London, UK; **Anna Bentkowska-Kafel**, **Vera Moitinho de Almeida**, Colour and Space in Cultural Heritage (www.COSCH.info); **Eryk Bunsch**, Laboratory for 3D Documentation, Museum of King Jan III's Palace at Wilanów, Warsaw, Poland; **Miroslav Hain**, Institute of Measurement Science, Slovak Academy of Sciences, Bratislava, Slovakia; **Julio del Hoyo Melendez**, Laboratory of Analysis and Non-Destructive Investigation of Heritage Objects, National Museum in Kraków, Poland; **Dirk Rieke-Zapp**, AICON 3D Systems GmbH, Meersburg, Germany; **Robert Sitnik**, Institute of Micromechanics and Photonics, Warsaw University of Technology, Poland; **Aurore Mathys**, Royal Belgian Museum of Natural Sciences, Brussels, Belgium; **Jaroslav Valach**, Institute of Theoretical and Applied Mechanics, Prague, Czech Republic.

Roman coins case study

This exploratory, interdisciplinary case study of ancient Roman silver coins involved examination and digitisation of two test coins. Various non-invasive imaging and analytical techniques were applied to identify and examine the properties and features of the coins, and to compare and evaluate the methods and multimodal results.

The two-year study (2014-2016) was undertaken by a group of scientists, cultural heritage researchers, conservators and museum professionals participating in the European network, Colour and Space in Cultural Heritage (COSCH), supported by the European Cooperation in Science and Technology between 2013-2016. This trans-domain COST Action (TD1201) is exploring high-resolution optical techniques, defining good practice and open standards for state-of-the-art documentation of material cultural heritage. The examination of Roman coins is one of six case studies undertaken by the COSCH Action.

Although museums increasingly use advanced digital techniques, numismatic collections often continue to rely on traditional documentation methods, predominantly black and white photography. Such representations are not accurate in terms of dimensional and colour information, and do not adequately convey the 3D surface structure.

Two Roman silver denarii of Faustina the Elder (following her posthumous deification in 140 A.D.) were selected as test objects to establish whether the proposed digital recording methods could support professional comparison of features and properties. The coins raise many interesting questions concerning their provenance, authenticity, design, purpose of issue, and historic usage. They also pose considerable challenges for recording due to their small size, material and surface properties.

The coins have been examined by a number of techniques, including:

- Photography and focus stacking (Figs 1 and 3);
- Dome photography giving image sets for PTM/RTI visualisation and photometric stereo (Figs 2, 5 and 6);
- X-ray microtomography for detection of cracks or impurities (Fig 8);
- Scanning electron microscopy (SEM) for surface detail;
- Energy-dispersive X-ray spectroscopy (EDX) elemental analysis (Fig 7);
- Micro X-ray fluorescence (XRF) spectrometry mapping;
- Laser / structured light scanning for 3D spatial capture (Fig 4);
- Photogrammetry with structure-from-motion (SfM) software.
- Quantitative geometric comparison of 3D surface models (Fig 9).

The results indicate the feasibility of such techniques for museum documentation and dissemination, and that they can usefully contribute to scientific examination of coins in general. The target beneficiaries are numismatic researchers and scientists, historians, collectors, conservators and educators. In particular the ability to generate high-resolution 3D models opens the way for greater public access to collections.

Publications/Website

The COSCH Action website is at: www.cosch.info
The images and 3D datasets of the Roman Coins project and associated reports will be accessible via: https://coschromancoins.wordpress.com

Results and analysis

Fig 1. (title image) Obverse and reverse of two silver Roman denarii depicting Diva Faustina. The images were taken by a Nikon D200 camera in an illumination dome. The specular component, from the mean of the four images illuminated from nearest the zenith, was combined with the diffuse (overall mean).

Fig 2. Coin A, obverse (detail). a) RTI capture UCL dome; b) RTI capture CyI dome; c) RTI capture RBINS Minidome, albedo mode; d) RTI capture RBINS Minidome, ambient mode; e) RTI capture Southampton dome; f) Focus stacked picture.

Fig 3. Coin A, focus stacking picture.

Fig 4. Coin B was scanned without any surface treatment. Colour information mapped from an external camera using add-on software to AICON´s scanning software.

Fig 5. Surface normals from photometric image sets.

Fig 6. Coin A photometric stereo from dome-photography. Final reconstruction of Faustina A obverse, viewed in *CloudCompare*.

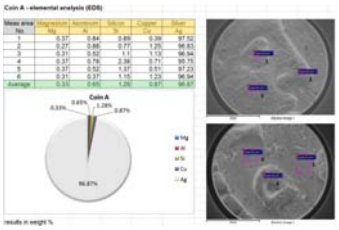

Fig 7. EDX elemental analysis of coin A.

Fig 8. Crack inside coin A, visualised by microCT method (three perpendicular microCT sections and rendered 3D model).

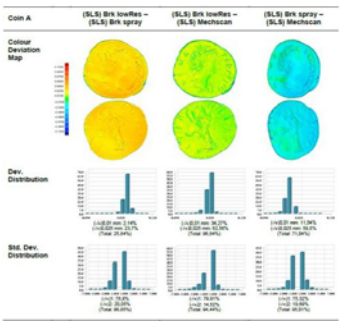

Fig 9. Pairwise differences between complete 3D models of coin A: Colour Difference Map, Distribution of differences, and Std. Deviation.

We wish to thank "Colour and Space in Cultural Heritage" (MPNS EU Cost Action TD-1201) for the opportunity to conduct this study. The networking activities of COSCH are funded by COST, an intergovernmental framework for European Cooperation in Science and Technology, allowing the coordination of nationally-funded research on a European level.

Contact: lindsay.macdonald@ucl.ac.uk
University College London, CEGE
Gower Street, London WC1E 6BT